Blogging in the physics classroom: A research-based approach to shaping students' attitudes towards physics

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Even though there has been a tremendous amount of research done in how to help students learn physics, students are still coming away missing a crucial piece of the puzzle: why bother with physics? Students learn fundamental laws and how to calculate, but come out of a general physics course without a deep understanding of how physics has transformed the world around them. In other words, they get the "how" but not the "why". Studies have shown that students leave introductory physics courses almost universally with decreased expectations and with a more negative attitude. This paper will detail an experiment to address this problem: a course weblog or "blog" which discusses real-world applications of physics and engages students in discussion and thinking outside of class. Specifically, students' attitudes towards the value of physics and its applicability to the real-world were probed using a 26-question Likert scale survey over the course of four semesters in an introductory physics course at a comprehensive Jesuit university. We found that students who did not participate in the blog study generally exhibited a deterioration in attitude towards physics as seen previously. However, students who read, commented, and were involved with the blog maintained their initially positive attitudes towards physics. Student response to the blog was overwhelmingly positive, with students claiming that the blog made the things we studied in the classroom come alive for them and seem much more relevant.

I. INTRODUCTION

An introductory physics course has many goals, some of which are explicitly stated in the syllabus and some of which are a bit more elusive. A great deal of progress has been made in recent years on these explicit goals – improving student learning and conceptual understanding in introductory physics and astronomy courses[1,2,3,4]. Physics education research has led to major improvements in student comprehension and learning by focusing on active rather than passive learning strategies in the classroom using a wide variety of diverse approaches such as Peer Instruction (PI)[5], Just in Time Teaching (JITT)[6], University of Washington style tutorials[7], Workshop Physics[8], and many others. However, those more elusive goals, aptly described as belonging to the "hidden curriculum"[9] remain difficult to address.

One goal which we believe is important to most, if not all, instructors and which clearly falls into the "hidden curriculum" category is to leave students with a positive attitude towards physics. This goes beyond simply "liking" physics; it encompasses an appreciation of how physicists think and operate, the value of physics as it applies to other fields such as engineering, biology, medicine, etc., and the applicability of physics to everyday life. To use JITT terminology, instructors would like students to see what physics is "good-for." Although we believe this is an important goal, physicists (and astronomers) have had little success addressing this dimension in the classroom.

In response to this concern, Redish, Saul, and Steinberg designed the Maryland Physics Expectations (MPEX) Survey, a 34-item Likert scale survey that examines "student attitudes, beliefs, and assumptions about physics"[9]. The intent was to study how introductory physics students' attitudes and expectations changed due to taking a physics course. As they write:

> "In all cases, the result of instruction on the overall survey was an *increase* in unfavorable responses and a decrease in favorable responses ... *Thus instruction produced an average deterioration rather than an improvement of student expectations."*

In other words, students' attitudes towards physics were more negative after taking an introductory physics course. This should certainly be a source of dismay to physics teachers.

Zeilik, Schau, and Mattern observed the same phenomenon in introductory astronomy courses[10]. Using data from over 400 students at the University of New Mexico in introductory astronomy courses they concluded that there was "little change over each semester in students' mildly positive incoming attitudes about astronomy and science." This change in attitude occurred despite the use of innovative assessment techniques such as concept maps, small group work, and identification of student misconceptions[11]. In other words, re-organizing a class to emphasize active-learning and employing novel assessment techniques did not seem to affect student attitudes towards astronomy.

More recently Adams et al. have developed a new instrument for measuring student attitudes and beliefs in introductory physics courses over a wide range of categories such as personal interest, real world connections and sense making, called the Colorado Learning Attitudes about Science Survey (CLASS)[12]. They found that, "most

teaching practices cause substantial drops in student scores". This phenomena is not unique to physics. Other disciplines, such as chemistry and statistics, have similarly begun to seriously examine the role and effect of students' attitudes in their respective fields[13,14,15,16]. In fact, when the CLASS instrument was modified for use in introductory chemistry courses at a large state research university the "results indicated that shifts after instruction were similar to, if not worse than, in physics in moving in the unfavorable direction"[12].

Why, however, should we worry about student attitudes? Most instructors aim to create an outgoing positive attitude towards physics, and educational research has repeatedly shown over the past few decades that learning is intrinsically linked with student attitude and expectations[17,18]. To cite just one specific example, Coletta and Philips (at Loyola Marymount) claim to have found a strong correlation between FCI gains[19] and MPEX scores for their students at Loyola Marymount University[20]. In other words, if we care about learning we need to pay attention to students' attitudes. The goal of this paper is to explore whether or not there is a way to positively impact student attitudes in an introductory physics course. To this end, we have examined the effectiveness of a course weblog or "blog" in shaping and guiding students' attitudes (see Blood's essay[21] for a primer on blogs in general).

But why use a blog? Obviously, blogs are an example of new technology which in and of itself may be appealing to increasingly technologically savvy students. However, technology should never be employed simply for the sake of showcasing technology. We use a blog due to the wealth of recent pedagogical research that has shown the value and validity of using blogs in both science and non-science courses[22,23,24,25,26,27]. For example, Ferdig and Trammel present some compelling arguments for blogging in the classroom, enumerating four primary benefits to student's involvement in blogs[26]: (1) when writing posts or comments students must scour through vast amounts of information on the web or in other references; this not only exposes them to a broad range of topics outside the classroom, but it also forces them to evaluate the validity and the value of various sources, (2) blogging tends to increase student excitement for learning and ownership of the process, (3) blogs open up discussions to students who may not otherwise participate in class, and (4) blogging encourages discussion outside of class with a wide variety of viewpoints.

Ferdig and Trammel also point out that, "current educational research and theory have demonstrated the importance of social interaction in teaching and learning"[26]; blogs provide a way for students to interact with each other and their instructor outside of class. Halavais also stresses the ability of blogs to move student learning outside the classroom[27]. And finally, Brownstein and Klein report that since the introduction of blogs in their classroom "the focus was moved from 'what' to 'why'", and that their students "see knowledge as interconnected as opposed to a set of discrete facts"[28]. Blogs appear to be a quite promising tool for addressing the "hidden curriculum" that we consider essential but that has been frustratingly elusive to pass on to our students.

Since this is such a large and open-ended question, as a first step we limit our focus on the effect on student attitude; the effect on student learning is left to be considered in the future. As our operational definition of attitude we use the MPEX concept of expectations, an all-inclusive set of beliefs, attitudes, skills, views on science and physics in general, and the value of physics[9]. This correlates with what the CLASS instrument refers to as "beliefs"[12]. We restrict our study of attitude to a sub-section of expectations/beliefs revolving around students' value of physics as it relates to their careers and the real-world, which the MPEX survey refers to as the "reality-link" category or the "real-world connections" category in the CLASS instrument.

Apart from the question of student attitudes in introductory physics classes, we hope that this study provides an example of how to apply the new technology of blogging to the physics classroom.

II. COURSE IMPLEMENTATION

General physics at Creighton University (CU) is taught in three to four sections of approximately 30 students meeting three times a week for 50 minute lectures, once a week for a one hour recitation section, as well as a two hour laboratory session. Traditional lectures are supplemented with active learning strategies such as Peer Instruction (PI)[5] and elements of Just in Time Teaching (JITT)[6] with recitation frequently making use of materials developed through physics education research such as ranking tasks and University of Washington style tutorials[7]. The corresponding laboratory section employs a mixture of Real Time physics and Workshop physics elements. Approximately 60-70% of the general physics students at CU are interested in the health professions (medical school, dental school, physical therapy, etc.). Due to local medical school entrance requirements (CU as well as the University of Nebraska), the general physics sequence is calculus-based, and pre-health students take the same sequence as physics majors and other physical science students. This student composition is a unique feature of physics at CU, and makes addressing the cross-utility of physics in other fields essential; one can easily imagine that engineers and scientists are far more likely to see the utility of physics than students focusing on biology and chemistry in preparation for a career in medicine.

This study was conducted over the course of four semesters as summarized below in Table I. In Semester I (Fall 2005) two sections, A and B, participated in the study while the remaining two sections, sections C and D, served as a

control group. In Semester II (Spring 2006) the blog was extended to all four sections in part due to overwhelmingly positive participating student feedback and in part due to demand from students who did not participate during Semester I. In Semester III (Fall 2006) all four sections again participated in the study, and in Semester IV (Spring 2007) only one section was included (mainly due to instructor turnover).

Semester	Date (number participant)	Instructors	Participated in blog study
Semester I	Fall 2005		
	(n=31)	Instructor A (GD)	yes
	(n=27)	Instructor B	yes
	(n=32)	Instructor C	no (control)
	(n=24)	Instructor D	no (control)
Semester II	Spring 2006		
	(n=36)	Instructor A (GD)	yes
	(n=35)	Instructor B	yes
	(n=33)	Instructor C	yes
	(n=25)	Instructor D	yes
Semester III	Fall 2006		
	(n=33)	Instructor B	yes
	(n=34)	Instructor C	yes
	(n=30)	Instructor D	yes
	(n=28)	Instructor E	yes
Semester IV	Spring 2007		
	(n=33)	Instructor A (GD)	yes

TABLE I: Summary of Semesters I-IV.

The blog was integrated into the course as follows: since reading the blog would be on top of the numerous assignments, reading quizzes, and exams that general physics students at CU already had to complete, we decided to assign the blog as extra credit. The course instructors (mainly GD) posted several times a week to the course blog. Students received two points of extra credit per week for (1) reading the posts to the course blog during the week and (2) for posting comments to one or more posts (each two points corresponded roughly to 2% on an exam or 0.2% of the overall course grade; in other words, by participating in the blog every week students could raise their overall grade by about 2.5%). The criteria for student comments were that they be a thoughtful and articulate reflection on the blog post, about a paragraph in length, that tied in outside information relevant to the topic in question. In other words, students had to move beyond a simple "This is cool!" response and include some actual content, much of which was the result of additional research on their part.

In terms of instructor workload, the average time spent on the blog (writing posts, responding to comments, recording credit) was approximately two to three hours per week. However, posting to the blog did not necessitate always re-inventing the wheel. For example, the website *How Stuff Works*[38] graciously gave permission to use their content on the blog, as long as it was for educational purposes, properly cited, and contained links which pointed back to their webpage. Quick posts at times were little more than an introductory paragraph followed by a link to a interesting article on, for example, the physics of television or the physics behind photocopying. In other words, weekly or bi-weekly blog posts did not have to be marathon projects, and often it was the short, link-type posts which students enjoyed the most. Posts were re-used (often with some improvement based on student input) between semesters (student comments were deleted so as to start with a blank slate); in this manner a "library" of blog posts was built up that could be rapidly and easily used in the future.

Since two to three hours per week is not a small investment of instructor time, a few additional comments on instructor workload are in order. Once a library of blog posts has been built up, as previously mentioned, the instructor time commitment drops to the time necessary to read student comments, record their participation, and answer questions on the blog. For a class of about 120 students in total at Creighton (with about 75% participating in the blog) we estimate that this entails roughly thirty minutes of work per week. Teaching assistants can be used to monitor the blog, answer student questions, and record participation. In this way, the blog is easily scalable to larger classes (however, more blog posts per week would be required to limit saturation of student comments or an

individual blog could be created for each section of the course). A complete set of blog posts has been posted at the EPAPS depository to cut down on the large initial investment of time for instructors interested in using the blog. And finally, we have had success in having students write their own blog posts for the class to read; this can involve some formatting work, however, students can be given access to the blog to work as a collaborative team.

Tables II and III below give a partial list of general physics topics with their corresponding blog posts (a version of the course blog from Semester II without student comments is still available for viewing[33] and Appendix II contains a blog post from Semester I with several actual student comments). Blog posts also integrated a wide variety of physics applets and videos available on the web. In particular, YouTube[34] proved to be a valuable resource which students were quite familiar with (and excited to see used in the classroom). For example, one blog post included a link to a YouTube video of a car being struck by lightning with the passengers none the worse for the experience; the video definitely caught students' attention and led to a natural discussion of Faraday cages (as well as students' critiques of the explanations provided on the YouTube comments for the video).

The content of the blog mainly focused on how the physics we were currently studying applied to the "real world" and other fields besides physics. The individual posts were written in the same theme as a JITT "Good For"[29], however there are some important differences. A physics "Good For" entails private communication between an instructor and an individual student whereas student responses to blog posts are public. Students respond in an open forum, react to each other's comments, and pose and answer questions. This had the effect of moving discussion out of the classroom. Whereas a physics "Good For" poses a specific list of questions to answer for credit, the blog post responses tended to be more open and flexible; students could use the post and bring in related topics that were of particular interest to them. Students interested in biology would often comment with biological examples; for example when discussing an application of static electricity a biology student discussed the importance of electrostatics in insect pollination. The blog was updated more frequently (2-3 posts per week), and tended to focus on topics specifically tailored to interest our health-science heavy classes.

For semesters I-III, Blogger[35], a free blog-hosting service, was used for the course blog. Haloscan[36], a free comment package for blogs, was used due to additional functionality over Blogger comments. Sitemeter was utilized to keep track of visits to the blog, particularly to make sure that CU general physics students were the primary visitors to the blog. By Spring of 2007 (Semester IV) CU had implemented its own blogging service utilizing WordPress[37], hence the blog in Semester IV was locally hosted. In terms of pedagogy and utilization it made little difference whether using Blogger or WordPress (other than the learning curve that the switch entailed for the instructor).

III. ATTITUDINAL SURVEY: THE INSTRUMENT

To measure students' attitudes towards physics, we utilized a 5-point Likert scale survey. The attitudinal survey used in this work is based on on the Attitude II survey designed by Zeilik, Schau, and Mattern[10] which was utilized in introductory astronomy courses at UMN, and which was obtained from the FLAG website[30]. The attitudinal survey was modified to specifically address an introductory physics course (rather than astronomy) with a few questions added. Two versions of the survey were given during the course of the semester: the pre-test which was administered on the first day of class, and the post-test which students completed at the end of the semester.

The attitudinal survey examines several dimensions: 1) affect, the positive and negative attitudes students may have towards physics, 2) cognitive competence, student's confidence in their intellectual skills and knowledge as applied to physics, 3) value, the worth and relevance of physics to student's lives, and 4) difficulty, a measure of the overall difficulty of physics to students. Our main modifications involved trimming the survey down from thirty-four to twenty-six questions, mainly by removing questions for the cognitive competence and difficulty categories. The survey is included as Appendix I, which also cross-correlates questions from this instrument to the MPEX and the CLASS tools and discusses the reliability and validity of the instrument. As mentioned in the introduction, particularly important to this work is the value category, which corresponds well with the "reality link" category of the the MPEX survey and the "real world connections" category of the CLASS instrument. We feel that the value category questions are similar enough to the corresponding categories from the MPEX or CLASS instruments to allow for a direct comparison with the trend of decreasing attitude[9,12]. We have left a few items on cognitive competence and difficulty; these, however, have not been analyzed and will be considered in future work.

We chose to utilize the Attitude II survey of Zeilik et al. rather than another instrument such as the MPEX, VASS[39], or CLASS for several reasons. First of all, the Attitude II survey contained far more questions which probed students' sense of the value of physics, precisely the dimension we were most interested in; for example, the MPEX survey contains only four questions in the "reality link" category. Since these surveys are Likert scales and class-sizes at CU are much smaller than at larger, public institutions, we felt that we would achieve more statistically significant results by probing students' value of physics with multiple questions. Also, the CLASS instrument had not yet been published when we began using the Attitude II survey in Semester I (August, 2005). However, as mentioned above,

Physics Subject Area	Blog Topic
1D Kinematics	Speed and Acceleration
Vectors	GPS System and Triangulation
2D Kinematics	Projectile Motion and Air Resistance
Uniform Circular Motion	Centrifuges and Carnival Rides
Newton's Laws	Physiological Effects of Acceleration
	The Magnus Force
	The Equivalence Principle
	Friction: How Geckos scale walls
	Non-inertial frames: Coriolis Effect
	Atomic Force Microscopy and nN
Energy	Einstein's Famous $E = mc^2$
	The Physics of *Armageddon*
	Energy Use and your Body
Fluid Mechanics	Archimedes and King Hieron's Crown
	The Venturi Effect
	Physics of Blood Flow
Conservation of Momentum	Collisions
Angular Momentum	Pulsars and Neutron Stars
	Torques and your Body
Gravitation	Satellites
Oscillations/Resonance	The London Millenium Bridge
	The Foucault Pendulum

TABLE II: General Physics I topics and corresponding blog posts.

we feel that the value items on the Attitude II survey match nicely with the corresponding categories on the MPEX and CLASS inventories.

IV. DATA ANALYSIS AND RESULTS

Likert scale data is generally evaluated using two different methods. The first treats the survey results as interval data (the differences between each response being equal) which allows the data to be simply summed and statistically analyzed. The second treats the survey results as ordinal data, meaning that the differences between each response are not equal and one should therefore examine the percentage of students who agreed vs. disagreed as the statistical measure. See the CLASS paper for an excellent discussion of the difference between interval and ordinal data[12]. We evaluate the attitudinal data in two different ways: 1) we group the value or "reality link" questions and perform a dependent-samples t-test and calculate an effect size (treating the Likert survey results as interval data), and 2) we use the agree-disagree plots and the binomial analysis presented to highlight changes both for clusters of survey questions as well as individual survey items (treating the survey results as ordinal data). We concentrate on the second method (treating the survey data as ordinal data) to compare our work to previous work on the subject; for example, both the MPEX and CLASS surveys are analyzed in this method as ordinal data.

Because students took the pre and post-tests anonymously in Semester I and III (fall of 2005 and 2006) we compare classes/sections as a whole. For Semester II (spring 2006) much more extensive data were compiled allowing for a more detailed statistical analysis. All students in the course completed both the pre and post attitudinal instrument. Due to relatively small class sizes, we have aggregated the data (in some cases by sections in some cases by students who read and posted to the blog versus those who did not) rather than reporting by each section to improve the statistical significance of the results.

Agree-Disagree plots, or more simply A-D plots or "Redish" plots, were first presented by Redish, Saul, and Steinberg in analyzing data from the MPEX Survey (treating the Likert scale survey responses as ordinal data)[9]. Strongly and weakly agree responses are combined together as are strongly disagree and weakly disagree to form overall agree and disagree values. These values are then plotted usually as favorable versus unfavorable responses

Physics Subject Area	Blog Topic
Electrostatics	Static Electricity
	Physics of Lightning
	Photocopiers
	Electric Eels
Magnetism	The MagnaDoodle
	The Earth's Magnetic Field
	Magnets and Mystic Healing
	Physics of Television
Capacitance	Shampoo Bottle as Capacitor
	iPod Touchwheel
Induction/Faraday's Law	Stereo Speakers
	Credit Card Readers
	The Forever Flashlight
	Induction Furnaces
Waves	How Bent Spaghetti Breaks
	Water Waves and Tsunamis
	Bad Science in *The Core*
Light and Optics	Mirages and Optical Illusions
	Solar Sails
	Polarization and Sunglasses
	Gravitational Lensing
	Lighthouses and Overhead Projectors

TABLE III: General Physics II topics and corresponding blog posts.

(for some survey items disagreement is a favorable result). A straight line is then plotted from a 100% favorable to a 100% unfavorable response; all student responses will fall within in area bounded by the favorable and unfavorable axes and this line. A-D plots are useful in that they visually portray all three dimensions of the data: the proportion of favorable and unfavorable responses is evident from the position on the A-D plot, and the proportion of neutral responses can be gauged from the distance from the diagonal line described above.

To analyze the statistical significance of A-D plots Redish, Saul, and Steinberg fit the data to a binomial distribution. If p and q are the percentages of students who answered favorably and unfavorably respectively (not considering neutral responses), then in order to fit a binomial distribution they introduce the following renormalization:

$$p' = \frac{p}{p+q} \qquad \text{and} \qquad q' = \frac{q}{p+q} \tag{1}$$

They considered a shift in A-D values to be significant if the difference was at less than the 5% probability level. In other words, the shift must be greater than 2σ where

$$\sigma = \sqrt{p'q'/n}, \tag{2}$$

and n is the number of students. Using their analysis, for example, for values of $p = 60\%$ and $q = 20\%$ with $n = 50$ we consider a shift of 12% to be statistically significant.

A. Semesters I and III: Fall 2005 and 2006

In Semester I the blog was offered as extra credit in two sections: Sections A and B, taught respectively by Instructors A (GD) and B. Sections C and D did not participate in the blog study to allow for a control group. There was almost 100% participation in Section A due to encouragement by the instructor; Instructor A (GD) frequently mentioned the blog in class and reminded students to check and comment on the blog. Participation in section B

was roughly 60%; Instructor B did not mention the blog besides the initial description of the extra credit available. In Semester I data was not keyed to individual students; students took the survey anonymously, although care was taken to ensure students took both the pre and post tests.

For Semester I, we take an average of the value or "reality link" questions for sections which participated in the blog study (A+B) as well as for the two sections which did not (C+D) both for the pre and post attitudinal survey. We plot these averages on an Agree-Disagree Redish plot as Fig. 1. We found that for the blog reading sections the agree-disagree values went from 69.7% favorable and 20.0% unfavorable on the pre-test to 69.7% favorable and 18.7% unfavorable ont the post-test, a statistically insignificant change. However, for the two sections which did not read the blog the agree-disagree values went from 71.7% favorable and 19.3% unfavorable on the pre-test to 60.6% favorable and 17.6% unfavorable on the post-test. For sections C+D there was an 11.1% decrease of favorable responses, which by the binomial distribution criteria is a statistically significant change. Hence, students on average who read the blog had maintained their initial positive attitude (with regards to the value or "reality link" aspect of physics) whereas students who did not read the blog saw a general deterioration of their initial positive attitude.

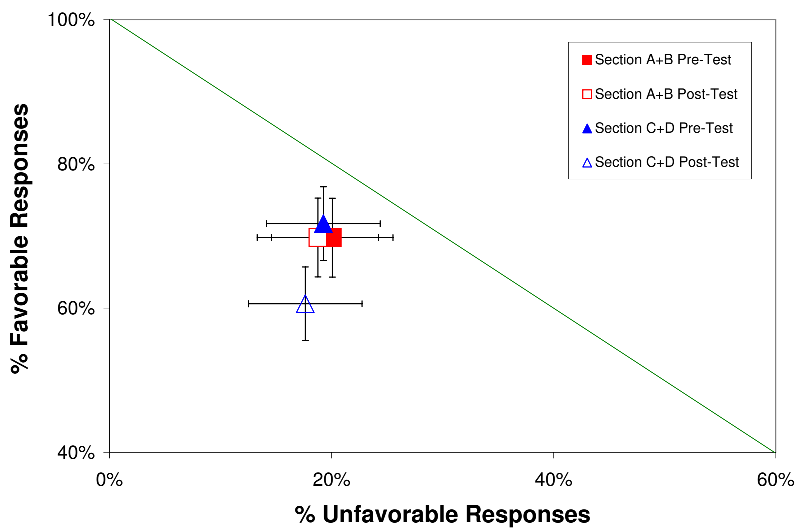

FIG. 1: A-D plot for Semester I (fall 2005) for sections which read the blog (A+B combined) and sections which did not participate in the blog study (sections C+D combined). Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.

In Semester III, on the other hand, all four sections read and commented on the blog. In Semester III there was a slight change of instructors; Instructor A (GD) was replaced by another instructor due to a scheduled junior-faculty leave. Instructor B took over administrating the course blog. Despite the change of instructors, the averaged value or "reality link" questions showed the same trend as for fall 2005. Students from Semester III (who all had the opportunity to participate and read the blog) maintained their positive attitudes as well as students from Semester I who had read the blog. The "reality link" average for Semester III went from 64.3% favorable and 18.2% unfavorable on the pre-test to 64.6% favorable and 15.4% unfavorable on the post-test. The data for both semesters are plotted as Fig. 2. This is one indication that the effect of the blog is not instructor specific; the effect of "instructor immediacy", to use a communication studies phrase, will be examined more thoroughly in a future work. We feel confident that the student population from Fall 2005 to Fall 2006 (all CU students with similar demographics such as major and class standing) was similar enough to allow a direct comparison between the two semesters.

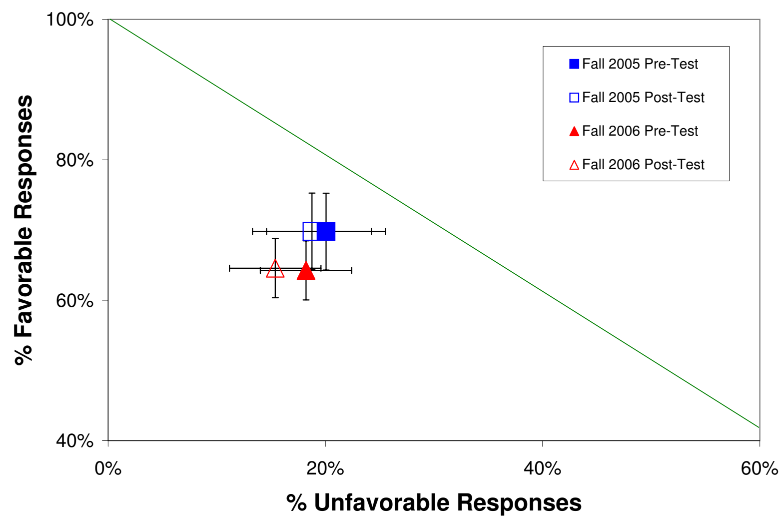

FIG. 2: A-D plot comparing students who participated in the blog from Semester I (fall 2005) with students from Semester II (fall 2006). Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.

B. Semesters II and IV: Spring 2006 and 2007

In Semester II the blog was offered as extra credit to all four sections of general physics. Instructor A (GD) was again responsible for writing and maintaining the blog; blog topics were frequently mentioned and discussed in section A. To offset the lack of a control group, responses on the attitudinal surveys were recorded for each individual student, allowing their attitudinal survey responses to be compared to blog participation, course grade, results on standardized assessment exams like the DIRECT and CSEM exams, etc[42,43].

A significant question to consider is who actually read the blog. If only the ‘A’ students were reading the blog, one might expect that any change in attitude was the result of over-sampling highly motivated students. However, upon examining the data, we found only a small correlation between blog participation and final course grade (with a correlation coefficient of 0.37); however, since blog participation acted as a source of extra credit the actual correlation is smaller (with a correlation constant of 0.27) when the extra credit is factored out of the final course grade. In other words, blog readership was not restricted only to the higher-achieving students; a broad spectrum of students in the course seemed to participate and find value in the blog.

Next, the average of the value or “reality link” responses from the attitudinal survey were analyzed for students who consistently read and commented on the blog (n=58) and for students who infrequently or never read or commented on the blog (n=37). Students from Sections A, B, C, and D comprise both groups. We found that although the pre-tests for the two groups were not statistically different, there was a large difference between the post-tests of the two groups. The blog-reading group’s attitude did not measurably change over the course of the semester (i.e. the initial positive attitude was maintained) whereas the non-blog reading group’s attitude deteriorated sharply. The survey results and statistics are presented in Table IV.

We also analyzed the Semester II (spring 2006) data by utilizing Agree-Disagree plots. Rather than presenting plots for all of the survey questions, we highlight a few examples here. Agree-Disagree values for both the pre/post attitudinal survey for question #7 (I will/did find it difficult to understand how physics applies in the real-world) are plotted as Fig. 3. Agree-Disagree values for Question #19 (Physics is not useful in my everyday life) are plotted as Fig. 4. Fig. 5a presents the average of the ‘reality link’ questions. All of the figures are plotted for two groups described above (students who read the blog frequently and those who didn’t). Fig. 5b includes the results from the MPEX “reality link” questions for Dickinson College (DC) and a small public liberal arts college (PLA), the two institutions from the MPEX survey closest in size and character to Creighton’s College of Arts and Sciences.

Question	Blog Pre	Non-Blog Pre	Statistical Significance	Blog Post	Non-Blog Post	Statistical Significance
1	70.8%	77.2%		75.5%	63.9%	
5	61.1%	66.6%		66.1%	53.9%	
7	73.2%	70.6%		75.2%	57.9%	
12	84.8%	83.2%	Not	81.8 %	73.4%	Statistically
15	70.7%	67.6%	Statistically	64.7%	58.6%	Significant
16	69.6%	66.3%	Significant	61.7%	57.9%	(ES = 1.51)
17	74.1%	71.7%		68.7%	63.2 %	
19	66.6%	70.8%		65.5%	58.9%	
20	69.8%	64.3%		66.2%	57.6%	
24	66.7%	64.3%		66.4%	58.8%	
Average	70.4%	70.3%		69.2%	60.4%	

TABLE IV: Results for all "reality link" questions for the attitudinal survey from Semester II (spring 2006); see Appendix I for the survey questions. Here the Likert scale survey results (N=58 for the blogging group and N=37 for the non-blogging group) were analyzed as interval data with an independent t-test (comparing pre-tests and post-tests between the blogging and non-blogging groups). The results above are averages over the responses for individual students for each group. The difference between the blog and non-blog reading groups was not-statistically significant for the pre-test but statistically significant with $p < 0.01$ for the post-test ($p = .0034$) and an effect size of 1.51. Scores have been normalized so that 50% represents a neutral response on the Likert-style attitudinal survey.

The expert response and responses from Ohio State University (OSU), a large public institution, were included for reference.

In all cases the blog-reading group had little change from pre to post test. However, the students who did not read the blog showed a statistically significant deterioration in their initially positive attitudes.

In spring 2007 only one section read the blog and the attitudinal survey was administered only for this section. The fact that only one section using the blog in spring 2007 was not a repudiation of the blog but rather a chance for other faculty to explore PER-type work in their own sections. In this semester the blog was integrated into the course and was no longer extra-credit; we were interested to see primarily if students' positive attitudes about the blog itself would survive if it were no longer extra credit but rather required. Because the number of students in the section was only n=33 and most students fully participated in the blog, it proved impossible to construct a large enough set to perform detailed statistics as for Semester II (for example, blog readership vs. attitude, etc.). However, we have compared the attitudinal change of the class with previous data. Fig. 6 compares the change in the average of the "reality link" questions from the attitudinal survey for students who participated in the blog study in Semester II (spring 2006) and all students in Semester IV (spring 2007) where the blog was required; in both instances students maintained their initial positive attitudes, and neither change from pre to post was statistically significant. One should be cautious however when directly comparing Semester II (spring 2006) and Semester IV (spring 2007) due to the differences in what role the blog played in the course.

Table V below summarizes the A-D values for Semesters II and IV (spring 2006 + 2007). Since questions #7 and #19 have favorable answers which correspond to students disagreeing with the statement, we have given favorable and unfavorable response percentages to avoid confusion.

V. STUDENT REACTIONS

Student reaction to the blog, even in Semester IV when it was no longer extra-credit, was overwhelmingly positive. For example, for spring 2006 and spring 2007 (Semesters II and IV) the vast majority of students found the blog interesting and were more interested in physics because of the blog. Student reactions to the blog are summarized below in Table VI. What is particularly striking is the fact that there was no large scale deterioration in the generally positive feeling for the blog in Semester IV (spring 2007) as compared to spring 2006 (Semester II); in Semester IV the blog was mandatory and students' posts counted as credit towards their final grade. In other words, the blog was popular with students even when it ceased to be extra credit.

In each semester a written blog questionnaire was distributed at the end of the semester to give students a chance to give written feedback on their blog experience. Students generally had very positive feedback about the blog; we

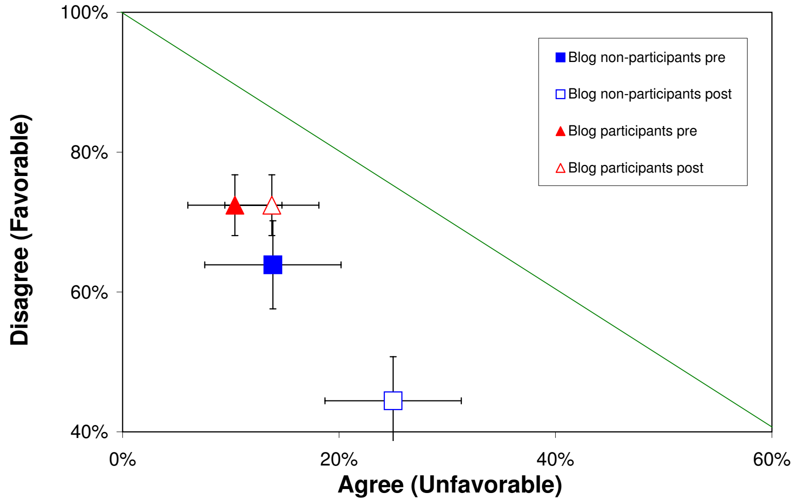

FIG. 3: A-D plot for Semester II (spring 2006) for question #7: "I will/did find it difficult to understand how physics applies in the real-world" for students who participated in the blog study and for students who did not read the blog. Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.

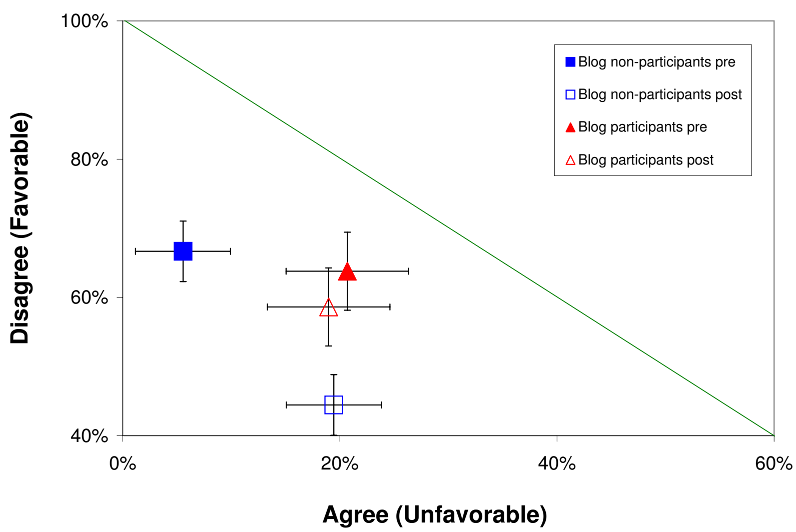

FIG. 4: A-D plot for Semester II (spring 2006) for question #19: "Physics is not useful in my everyday life" for students who participated in the blog study and for students who did not read the blog. Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.

	Pre-test		Post-test		Statistical
	Favorable	Unfavorable	Favorable	Unfavorable	Significance
Reality link avergage					
Spring 2006 - blog	67.%	10.9%	65.1%	14.5%	not significant
Spring 2006 - no blog	64.2%	8.0%	49.1%	18.5%	significant (shift $\approx 3\sigma$)
Spring 2007	79.7%	11.0%	77.3%	14.3%	not significant
Q7: I will/did find it difficult to understand how physics applies in the real-world					
Spring 2006 - blog	72.4%	10.3%	72.4%	13.8%	not significant
Spring 2006 - no blog	63.9%	13.9%	44.4%	25.0%	significant (shift $> 3\sigma$)
Q19: Physics is not useful in my everyday life					
Spring 2006 - blog	63.7%	20.7%	58.6%	19.0%	not significant
Spring 2006 - no blog	66.7%	5.6%	44.4%	19.4%	(shift $> 5\sigma$)

TABLE V: Student A-D values for plotted spring 2006 + 2007 items. The Likert scale survey results were analyzed as ordinal data here using the binomial agree/disagree analysis presented in the MPEX paper. σ is calculated using Eq.(2); a shift of $> 2\sigma$ is considered statistically significant.

	Spring 2006		Spring 2007	
Attitudinal Survey Question	Agree	Disagree	Agree	Disagree
The blog made the class more interesting to me	80.2%	19.8%	73.3%	26.7%
The blog helped improve my learning in this class	60.3%	39.7%	52.2%	47.8%
I am more interested in physics due to the blog	68.7%	31.3%	66.7%	33.3%
I am glad we had the course blog	85.4%	14.6%	65.2%	34.8%
The course blog would have been valuable even if we didn't earn (extra) credit	50.7%	49.3%	65.2%	34.7%

TABLE VI: Student Post-test reactions to the course blog in Spring 2006. The 5-pt Likert data were fit to a binomial agree-disagree scale as described earlier.

give some example student responses below.

> "It made it easier to appreciate physics. It's so boring talking about blocks and strings and bike wheels, but talking about planets and bigger things was great." – Student #1

> "It made me aware of just how much physics impacted our everyday lives. It also made me realize that physics is in fact useful in my profession (and many more) when I originally couldn't see the connection." – Student #2

> "I'm a little bit more interested [in physics], and the blog definitely helped! It was fun and interesting and true to life, not the 'ideal situation' physics class deals with." – Student #3

> "It is often hard to see physics at work in everyday life, especially compared to biology. The blog gave me a greater appreciation for physics and motivated me to do my homework!" – Student #4

> "The blog made me feel like I could interact with the class more. At 8:30 am you don't feel like getting involved!" – Student #5

Despite the fact that the blog entailed time outside of class, students enjoyed reading the posts, commenting and asking questions, and being able to interact with their classmates in a new way. Many students were passionate supporters of the blog, going as far to say that it was their favorite component of the course. A common theme which emerged was that students appreciated the chance to see how physics was applied to the real world, and how physics had a great deal to say about systems far more complex than those dealt with in class.

VI. CONCLUSIONS

In this paper, we have explored the effect of students' participation in a course weblog on their overall attitude towards the value of physics principles learned in the introductory physics classroom. The course blog featured postings about various modern applications of physics in areas of technology and nature, and encouraged students to conduct further research and exploration, discuss with other students, and pose questions. This was designed to provide the students with a real world vision of physics, rather than one that revolves around the more mundane and necessarily simple examples that can be covered in class.

Students' attitudes and perceptions of the importance and value of physics were examined using a 5-pt Likert scale attitudinal survey which was given as a pre and post test for four semesters of introductory physics. From the data gathered using this attitudinal survey, we can answer the main question raised in this paper: can the use of a semester-long blog have a significant, positive impact on how students feel about the relevance of physics? Looking at the average responses of the "reality link" questions on the survey, we see that those students who did not read the blog in semesters I and III had a statistically significant deterioration in attitude over the course of the semester, while those who did participate in the blog in each of the four semesters showed little, if any, change; in other words, the initial optimistic attitudes students tended to start the course with remained. When compared with the results of other universities on the MPEX "reality link" items, we can see that the students at CU who did not participate in the blog are comparable to those from other institutions. In a more explicit manner, students in semesters II and IV were asked if they personally felt that the blog improved their overall experience in general physics. On each of these questions, over half (ranging from 50.7% to 85.4%) of the students responded in a positive manner. The students felt that overall, the blog was helpful in learning the material covered in the classroom, made physics more interesting, and was generally enjoyable. These encouraging results reflect the sustained positive attitude of blog participants on the more indirect "reality link" questions.

In the introduction we detailed four potential benefits of blogging from Ferdig and Trammel[26]; while writing and maintaining the blog we saw these benefits become tangible to our students. In writing comments to posts on the blog students were forced to do outside research, learning about areas of physics that weren't covered in class; for example, in the Little Green Men post reproduced as Appendix II, students researched a bit about the life and death of stars, stellar nucleosynthesis, and black holes. Table VI shows that the blog made class more interesting for the vast majority of students, and that students were more interested in physics due to the blog. Time and time again we saw students who never participated or asked questions in class being very vocal and interactive on the blog; students felt comfortable asking questions and often (instead of waiting for the instructor) answered other students' questions. And finally the blog got students thinking about and discussing physics outside the classroom. SiteMeter[44] statistics show that most blog comments were posted late into the night when students are most active and which is outside of the traditional hours of instruction and instructor-student interaction.

Finally, because attitude and learning go hand-in-hand, and because of the continuously increasing use of technology (and therefore physics) in our world today, it is essential to explore why perceptions of the value of physics generally become more negative after a semester of instruction and how to combat this. In addition, studies have shown that undergraduates are withdrawing from majors in the physical sciences despite demonstrating an ability to succeed in such courses[41]; this fact should be alarming to any instructor in the sciences making student attitudes even more important. If students cannot make solid connections between physics learned in the classroom and how the world works, they will probably lose interest and leave the semester questioning, "Why was this important?" Or, in extreme cases, this negative attitude may drive undergraduate physics majors to choose other areas of study.

With these many concerns in mind, we hope to have supplied an example of how to apply a blog to an introductory physics class as an effective way to study and improve at least a subset of student attitudes (the real-world connections of physics), as well as to help lay the foundation for further research into this topic.

VII. ACKNOWLEDGEMENTS

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VIII. APPENDIX I: THE ATTITUDINAL SURVEY

A. Survey Items

In the table below we give the complete list of items for the attitudinal survey. Starred items, we believe, correspond well with the MPEX “reality link” category or the “real world connections” category on the CLASS inventory. The items denoted with a † are the items included in the averages over “reality link”-type questions; these were the items we felt most directly related to the blog and which had the highest internal consistency and reliability.

	Survey Item
1†	Physics is irrelevant to my life*
2	I will (did) understand how to apply analytical reasoning to physics
3	I will have (had) no idea what’s going this semester in physics
4	I will (did) like physics this semester
5†	What I learn in physics this semester will not be useful in my career*
6	Physics is highly technical
7†	I will (did) find it difficult to understand how physics applies in the real-world*
8	I will (did) enjoy taking this physics course
9	Physics is purely memorizing a massive collection of facts and formulas
10	Physics is a complicated subject
11	I can (did) learn physics
12†	Physics is worthless
13	I see and understand physics in technology and the world around me*
14	I am scared of physics
15†	Skills I learn in physics will make me more employable*
16†	I can use physics in my everyday life*
17†	Physics is not applicable to my life outside school*
18	Physics should be a required part of my professional training
19†	Physics is not useful in my everyday life*
20†	I will (do) look at the world differently after taking this class*
21	Physics is useful to science or medical professionals in all fields*
22	What I learn will be applicable to my life outside my job*
23	Physics should be required as part of my professional training*
24†	Physics this semester will (did) make me change some of my ideas about how the world works*
25	This semester of physics will be (was) interesting
26	I am glad I am taking (took) this class

B. Reliability

The attitudinal survey we use in this study grew out of a statistics instrument (measuring the attitude of statistics students towards that topic) and was later employed by Zeilik et al.[10] in astronomy courses at the University of New Mexico. Since this survey has not been as rigorously utilized and tested as the MPEX and CLASS surveys we performed several tests to demonstrate the reliability and validity of the attitudinal survey.

To test the reliability of the survey we calculated a Cronbach-alpha value (a measure for the internal consistency of the instrument) for the reality link questions on the attitudinal survey. Table VII gives the Cronbach-alpha values for the reality link items in the instrument for various semesters.

In comparison, the MPEX survey has an alpha of 0.67 for the reality link cluster; the overall MPEX survey has a Cronbach Alpha of .806. In this Ph.D. thesis detailing the development of the MPEX instrument, Saul uses the value of 0.7 as the lower limit for an Alpha for a test that can be considered reliable[40].

In spring 2008 an essentially random group of students (n=26) in general physics were given both the attitudinal survey and the CLASS instrument (in essence to test the validity of the attitudinal survey). Although this group

Semester	Number	α value
Spring 2006	(n=94)	0.85
Spring 2007	(n=28)	0.70
Spring 2008	(n=78)	0.87
Average	(n=200)	0.84

TABLE VII: Cronbach-alpha values for the reality link cluster questions in the attitudinal survey. Spring 2008 data (not used elsewhere) is included only to gain further confidence in the reliability of the instrument.

is not included in this study (due to different methodologies and a different phase of the blog study), we wanted to determine if the attitudinal survey we use gives similar results to a well-tested survey like the CLASS. Table (VIII) gives the correlation coefficients between the ClASS and attitudinal surveys.

Cluster	Correlation Coefficients
Reality Link	0.70
Personal Interest	0.72
Problem Solving Confidence	0.25

TABLE VIII: Correlation coefficients between the results of the attitudinal survey and the CLASS instrument for questions corresponding to three separate clusters (n=28, spring 2008).

Although this sample is of limited size, we can conclude that students' responses to reality link questions correlate strongly between the attitudinal survey and the CLASS instrument. This gives increased confidence that both instruments measure students' attitudes towards the "connection between physics and reality - whether physics is unrelated to experiences outside the classroom or whether it is useful to think about them together" as defined by the MPEX survey[9].

IX. APPENDIX II: SAMPLE BLOG POST

Below we include a sample blog post used in Semesters I and III relating to angular momentum as well as several student comments. Pictures and hyperlinks have been removed.

A. Blog Post: Little Green Men and Pulsars

For today's blog entry I want to share an interesting example of conservation of angular momentum. Our story starts in 1967, where graduate student Jocelyn Bell was constructing a large radio telescope (at 81.5 MHz) at Cambridge University in England. The radio telescope consisted of receivers mounted on tall poles (about 9 feet tall), strung together by wires, with the whole assembly covering several acres of land. Bell's job was to monitor the output of the radio telescope; this meant painstakingly going through about 250 m of charts that were produced every four days. Bell noticed a strange signal in the data which she at first attributed to noise or interference. However, upon closer examination it appeared that the signal was not noise at all, but a repeating signal coming from outside the solar system (the signal source moved at the same rate as stars in the sky, showing it was not a manmade signal nor a signal coming from nearby). The signal repeated itself every 1.339 seconds and was very regular. Bell and her advisor, Anthony Hewish, named the source of the signal LGM-1, or Little Green Men-1; it was seriously thought at the time that this might be the first detection of an extraterrestrial signal. Hewish and Bell published their results in the journal Nature, which sparked lively debate in astronomical circles about the source of the signals. Eventually other pulsating radio sources like the one discovered by Bell were found, which convinced astronomers that they were looking at a natural, not extra-terrestrial signal.

So, what created the signal Jocelyn Bell discovered? To understand what she had found we need to learn a little bit about stars and stellar evolution. It turns out that stars are not eternal, but are born and die just like everything else in the Universe. Stars spend most of their lives (about 20 billion years for a star like our Sun) burning hydrogen in their core into helium through the process of nuclear fusion (putting four hydrogen nuclei together to form a helium nucleus releases tremendous energy). The energy released by fusion is transported through the star and eventually reaches us on Earth. During its whole lifetime, a star is in a state of careful balance. Energy generation through nuclear fusion tends to expand the star while gravity tends to try to collapse the star. As long as the star can generate energy through fusion, gravity and collapse are held at bay.

However, very massive stars (stars like Betelgeuse with masses 10x or so of our Sun's mass) can eventually run out of hydrogen in the core to burn and produce energy. A series of run-away reactions occurs, and the stars begins to burn heavier and heavier elements in its interior. Finally after burning hydrogen to helium, then helium to carbon, and so on, iron is formed in the core. Iron is a special element in that in order to fuse iron you need to add energy rather than getting energy out (it's an endothermic reaction rather than an exothermic). So the star can no longer forestall gravitational collapse by producing energy in the core. The star collapses and then explodes in what astronomers call a supernova. Even though a galaxy like our Milky Way contains about 100 billion stars, one supernova can briefly outshine the entire galaxy.

Although you might think that the star is completely obliterated in such an explosion, the core of the star actually remains. The core has been so squeezed by gravity that electrons and protons have combined to form neutrons. The leftover core is called a neutron star. Our sun's diameter is about 1.3×10^6 km, but a neutron star is only about 25 km in size. The gravity of a neutron star is so strong (because of its mass and its small size) that the acceleration of gravity on the surface is not 9.8 m/s^2 but about 10^{11} m/s^2.

So what does this have to do with the pulsating radio objects (or pulsars) that Jocelyn Bell discovered? Well, Bell's pulsars are actually neutron stars that are rotating very, very rapidly. In fact, the rotational speeds of neutron stars are almost unbelievable. So why do they rotate so quickly? Actually it comes down to simple conservation of angular momentum; as a star collapses into a supernova, the angular momentum of the star must remain conserved. For example, a star like our Sun has a angular speed of about 2×10^{-6} rad/sec (it rotates once in 25.38 days) and a radius of about 10^6 km. If our sun were to collapse to a neuron star with a radius of only 25 km, we could use conservation of angular momentum to find the final rotational velocity. We know that

$$I_i \omega_i = I_f \omega_f$$

And since the moment of inertia for a sphere is 2/5 MR^2, we can solve for the final angular velocity:

$$\omega_f = (R_i^2 / R_f^2) \omega_i$$

Plugging in numbers gives $\omega_f \approx 8700$ rad/sec or a rotational period of about 7×10^{-5} sec. That's pretty darn fast! And since rotational kinetic energy goes like ω^2, a rotating neutron star, for such a small object, packs quite a lot of rotational energy.

The reason that pulsars or rotating neutron stars give off energy as radio pulses is that some of the rotational kinetic energy is being converted to radio energy as the pulsar slows down. As a pulsar or neutron star rotates, thin beams of radiation speed through space, like the beam of a lighthouse. It was these beams that Jocelyn Bell and the radio telescope at Cambridge discovered. For more information about pulsars I suggest starting at Wikipedia's entry here.

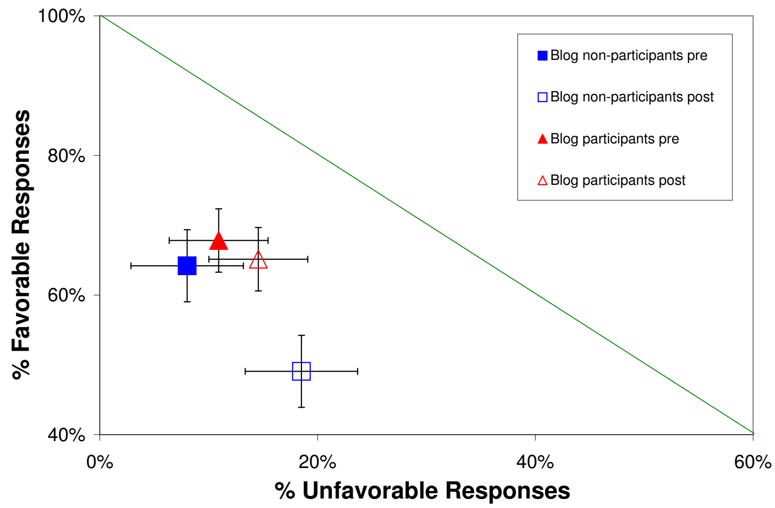
So, to conclude, what I find fascinating about physics is that a simple experiment like sitting on a rotating stool and watching your rotational speed change as you bring your arms in and out can actually explain the workings of something as incredible as a rotating neutron star. Physics done in the lab actually controls how things work out in the Universe. So when we say conservation of angular momentum is a fundamental principle we really, really mean it!

B. Sample Student Comments

> "This was so interesting! We always learn in class that the laws of physics do not change...but often, it does not occur to me that they operate in something as small as a molecule or something as big as a star! Those little neutron stars rotate so fast and have so much energy in them that even though they are so far away we can still see the effects here on Earth, as Jocelyn Bell discovered. The black hole thing is interesting too...I am wondering- how did scientists figure out the mass at which the gravity would cause the star to collapse? This phenomenon does not occur anywhere else in nature, so how can we possibly know how it happens? Amazing!" – Student #1

> "What I found most interesting doesn't really have anything to do with angular momentum. I am curious to how one supernova can briefly outshine the entire galaxy, even though a galaxy like the Milky Way contains about 100 billion stars. That is a lot of outshining to do! So I did a little research and didn't find an answer but I did find this - supernova explosions are the main source of all the elements heavier than oxygen, and they are the only source of many important elements. For example, all the calcium in our bones and all the iron in our hemoglobin were synthesized in a supernova explosion, billions of years ago. Who would have thought?" – Student #2

> "I agree with [another student]; this is by far the most interesting blog post yet! After my instructor mentioned neutron stars in class (and did some of the angular momentum equations) I became very fascinated and did a little research on my own. I learned that neutron stars are about the size of Manhattan island, but are more massive than the sun. I also learned that if you could somehow get your hands on a tablespoon-sized piece of a neutron star it would weigh a billion tons. Pretty tough to get your head around huh? Some of the sites I visited noted something about these neutron stars being superfluid; I was under the impression that they were nearly solid iron....any clarification?" – Student #3



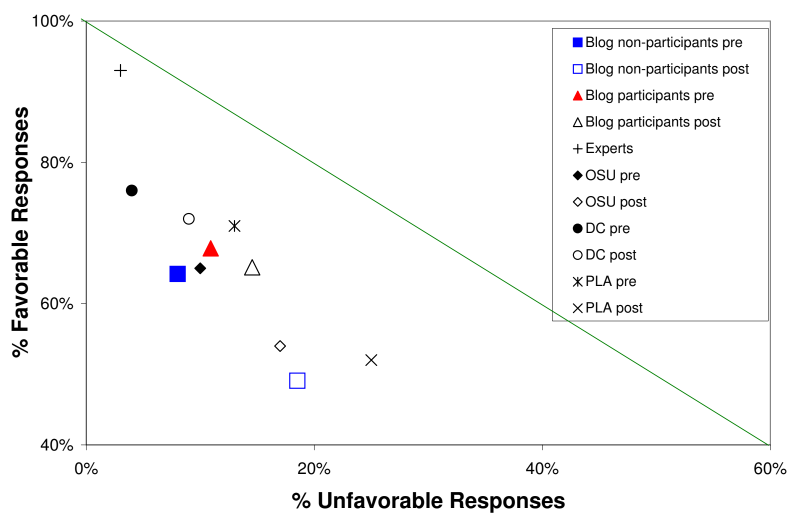


FIG. 5: Top: A-D plot for Semester II (spring 2006) for an average of the "reality link" questions; Bottom: same as above but with data from the MPEX Survey[9] included for comparison. Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.

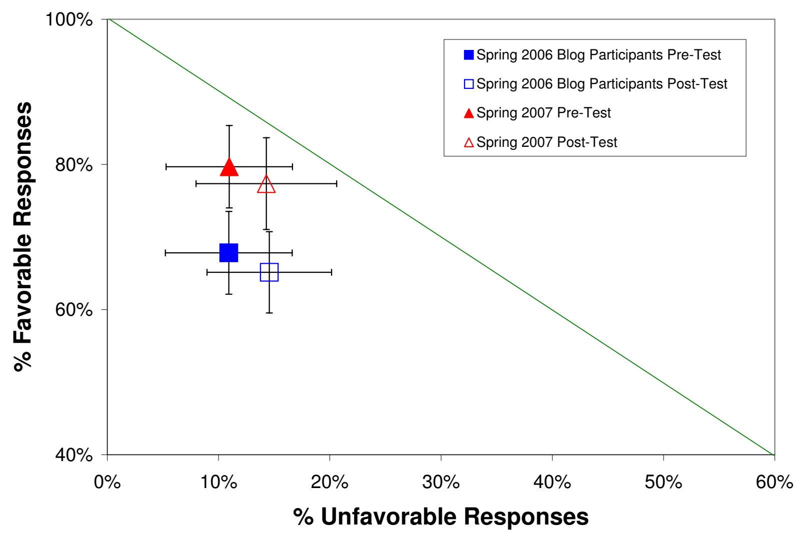


FIG. 6: A-D plot comparing students who participated in the blog from Semester III (spring 2006) with students from Semester IV (spring 2007) in which the blog was a required element of the course. Error bars are 1σ, where σ is calculated using Eq.(2). In the binomial analysis a shift of $> 2\sigma$ is considered statistically significant.